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Stereo-refraction: Its effect on far-point cylinder findings

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INTRODUCTION

This thesis done in partial fulfillment for the degree of DOCTOR OF OPTOMETRY, represents an original research project done by Gary E. Eudaily, Jon Elston, and Larry Henningsgaard, clinicians at the College of Optometry, Pacific University, Forest Grove, Oregon. The research was to determine what, if any, changes occur in far point cylinder power and/or axis when obtained by means of a three-dimensional, stereo-refraction technique as compared to those results obtained with the standard, bi-dimensional technique.

ACKNOWLEDGEMENTS

We wish to express our sincere thanks to Dr. Jane Brent Carmichael who acted as our faculty advisor for this study, and to Dr. Elizabeth Brody for her many hours of work helping us prepare the statistical analysis used herein.

HISTORY:

It has been long accepted in optometry that an equalization of the two eyes is of utmost importance in influencing binocularity. Almost as universally accepted is the fact that our methods for achieving this balance have been at best rather uncertain. This problem has led to the innovation of several different optometric techniques designed to eliminate this uncertainty.

Turville[1] published a description of a technique in 1936 which has been rather widely accepted in the British Isles, but has not been used to any great extent here in the United States, mainly because of its slowness.

The Turville system consisted of a test chart with two fields of letters spaced 60mm apart, set at 6m. This chart was reflected to a patient from a mirror placed at a 3m distance. The mirror was bisected by a metal or ground glass septum of 3cm width. This enabled the patient to see one set of letters with his right eye while the other set was seen with his left eye. A black border around the chart served as a stimulus to peripheral fusion, as did the septum. While this set-up served to provide some sort of control of binocularity, one can see that an exaggerated fixation disparity has been created.

The importance of good binocular balance has been noted by various other authors; for example, Sugar[2] and Shreve[3] have both reported that there may be changes in the axis of monocular astigmatism when binocular

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[1] I. Borish, Clinical Refraction, pp. 291-293.

[2] H.S. Sugar, "Binocular Refraction with Cross Cylinder," Arch. Ophth, Jan. 1944.

[3] J.R. Shreve, "Elimination of Cyclophoria as a Factor in Astigmatic Correction," Am. J. Optom. and Arch. Am. Acad. Optom., 1947.

vision is obtained. This shift of axis may be due to a cyclotorsion of the eye, when the visual pattern is shifted from a monocular condition to a binocular condition.

Norman[4] has found a significant difference in binocular plus acceptance from that found monocularly. He has utilized polaroid filters and specially designed charts, usable for test procedures from equalization to stereopsis. Polaroid filters have also been used by Wilmut[5] to modify the Turville technique. Since the chart is polarized, no septum is needed, and peripheral fusion is obtained by unpolarized borders on the chart. Several different charts were used, all of which created some kind of fixation disparity.

Copeland[6] proposed that the addition of a 2.00 sphere, over the retinoscopic finding be added before the eye not being tested. This blur would allow proper fixation, but would destroy the possibility of acute discrimination through this eye.

Luckeish and Moss[7] developed a similar procedure using a neutral filter to destroy acute discrimination rather than a plus lens. The basic objection to both of these methods is that it is impossible to make a rapid shift from one eye to the other.

One of the most recent advances in binocular refraction is the

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[4] S.L. Norman, "Binocular Subjective Refraction With the Polaroid Occluder," Opt. Weekly, Nov. 9, 1950.

[5] E.B. Wilmut, "The Use of Polarizing Filters for Infinity Balance Examination and Near Correction," Trans. Int. Opt. Cong., 1951.

[6] J.C. Copeland, Locating the Astigmatic Axis under Binocular Fixation, Ten Years of Optical Developments, Nov. 1940.

[7] M. Luckeish and F.K. Moss, "A New Method of Subjective Refraction Involving Identical Techniques in Static and Dynamic Tests," Arch. Ophth, May, 1940.

development of stereoscopic slides. Frantz[8] refers to this method as the most suitable binocular refraction technique ever developed for use in the modern optometric office. It was from this technique of using polarized stereo slides and polarized acuity material that our own binocular refraction technique was developed.

[8] Don A. Frantz, "A Review of Three-Dimensional Refraction," The Optometric Weekly, pp. 23-30.

PROCEDURE:

All examinations were done in a standard twenty-foot refracting room using an A.O. Rx-Master. The bi-dimensional refractions were done in the manner customarily used at the College of Optometry, Pacific University. These refractions consisted of a 20/30 blur finding, starting from a high fog; a clock dial cylinder test; a Jackson cross cylinder test, used to refine the clock dial; and a red-green balance test for monocular sphere power.

Refractions done under both sets of conditions were accomplished with the use of polaroid controls. We found it easier to construct our own polaroid filters and analyzers out of sheet polaroid, as there are very few commercially available devices that were suitable for our purposes. The entire set-up consisted of five pieces of sheet polaroid: one over each lens-well on the phoropter (90 degrees removed from each other); one over each tube of the stereo slide projector (90 degrees removed from each other and oriented to coincide with those on the phoropter); and finally one over the standard A.O. projector that we used for the acuity material and clock dial, etc. This last polaroid was constructed so that it could be rotated on the end of the projector tube and in this manner could be used to present a clock dial, for example, polarized in such a manner that only the right eye could see it, even though an entire polarized stereo slide was being viewed binocularly.

The stereo slides used for this study were taken specifically for this use by the clinicians. They consist mostly of outdoor scenes. We found that this was necessary to achieve the desired depth effect. We found that any of the various kinds of outdoor slide film worked well for our purposes. However, we decided to use Ectachrome X and a Kodak Stereo Camera.

Extreme care was taken to try to eliminate any effect induced by our refraction procedure itself. Patients were selected at random from both the student body at Pacific University and from the usual out-patient clinic at the College of Optometry at Pacific. Random chance determined which of the two refraction techniques was to be used first--ie: some patients were tested using the stereo conditions first and others using standard bi-dimensional techniques. Refractive errors were not considered in the selection of patients--they ranged from a 4.50 diopter myope to a 5.00 diopter hyperope, with most patients grouped closer to the mean of a random sample of the population.

DATA:

It becomes immediately apparent when looking at Tables 1 and 2 that there have been some gross changes in results in shifting from bi-dimensional refraction techniques to stereoscopic ones. It is almost as immediately noticeable that the changes in cylinder axis that have occurred are quite insignificant. In fact, in the majority of cases, no change in axis or a change of only 2-3 degrees has occurred. Quite obviously the major change that is observed is the change of cylinder power.

At first glance, the data in Tables 1 and 2 seems to reveal an extremely clear-cut picture: in most instances there appears a slight increase in minus cylinder power using the stereoscopic refraction techniques we developed. There also seems to be a definite correlation between right and left eyes. A statistical evaluation, however, shows that this is not the case.

Table 3 shows that the approximate mean change for both the left and right eyes was +.25 diopters, but that a change in the cylinder power in the left eye was not at all related to a change of power in the right eye. (We have assigned a plus (+) value to those cases that took more minus cylinder under stereoscopic conditions.)

The lack of correlation between the right and left eyes in the matter of cylinder power is the most disturbing item we uncovered. This prompted us to do a more complete analysis of the data in this area which led to the results shown in Table 4.

PATIENTS SHOWING A CHANGE OF CYLINDER POWER ON THE J.C.C.

RIGHT EYE

Patient #	Bi-dimensional	Stereoscopic	Power Difference
1	-75 x 32	-1.12 x 25	+.375
2	pl	-.25 x 160	+.25
3	-3.25 x 180	-3.75 x 3	+.50
4	pl	pl	0.0
5	-.62 x 150	-.50 x 153	-.125
6	-1.00 x 3	-1.37 x 5	+.375
7	-3.50 x 4	-3.25 x 5	-.25
8	-.37 x 25	-1.00 x 23	+.625
9	-.50 x 90	-1.00 x 93	+.50
10	-1.00 x 175	-1,25 x 170	+.25
11	-.25 x 88	-.75 x 88	+.50
12	-1.00 x 90	-1.25 x 90	+.25
13	-.50 x 105	-.87 x 100	+.375
14	-.25 x 165	-.37 x 165	+.125
15	-.25 x 180	-.37 x 175	+.125
16	-.37 x 56	-.62 x 54	+.25
17	-1.00 x 163	-1.25 x 167	+.25
18	-.50 x 90	-1.00 x 94	+.50
19	pl	-.50 x 90	+.50
20	pl	-.25 x 160	+.25
21	-.37 x 75	-.50 x 75	+.125
22	-1.00 x 100	-1.25 x 90	+.25
23	-1.00 x 55	-1.25 x 47	+.25
24	pl	-.50 x 175	+.50
25	-1.50 x 85	-1.25 x 85	-.25
26	-.25 x 30	-.50 x 32	+.25
27	-4.75 x 180	-4.87 x 180	+.125
28	-.25 x 95	-.37 x 90	+.125

Mean Difference = +.2500

Variance, s = 0.219

Tee score = 5.94

(n-1) = 27

TABLE 1

PATIENTS SHOWING A CHANGE OF CYLINDER POWER ON THE J.C.C.

LEFT EYE

Patient #	Bi-dimensional	Stereoscopic	Power Difference
1	-.50 x 165	-.75 x 163	+.25
2	pl	-.12 x 70	+.125
3	-1.62 x 180	-2.25 x 180	+.625
4	pl	-.25 x 48	+.25
5	-1.00 x 25	-1.25 x 27	+.25
6	-1.00 x 180	-1.37 x 1	+.375
7	-3.25 x 180	-3.50 x 175	+.25
8	-.75 x 180	-.87 x 180	-.125
9	-.50 x 93	-1.00 x 92	+.50
10	pl	pl	0.00
11	-.25 x 115	-.75 x 120	+.50
12	-1.00 x 90	-1.25 x 90	+.25
13	-.50 x 50	-.75 x 50	+.25
14	pl	-.37 x 5	+.375
15	-.25 x 171	-.37 x 170	+.125
16	-.50 x 92	-.75 x 93	+.25
17	-.75 x 25	-1.00 x 40	+.25
18	-1.00 x 60	-1.25 x 61	+.25
19	pl	-.25 x 97	+.25
20	-.25 x 155	-.50 x 150	+.25
21	-.50 x 50	-.62 x 35	+.125
22	pl	pl	0.00
23	-1.50 x 165	-1.75 x 160	+.25
24	-.50 x 5	-.75 x 180	+.25
25	-1.00 x 85	-1.25 x 86	+.25
26	-.37 x 5	-.87 x 5	+.50
27	-3.25 x 160	-3.50 x 165	+.25
28	-.25 x 81	pl	-.25

Mean Difference = +.246

Variance, s = 0.155

Tee score = 8.25

(n-1)= 27

TABLE 2

Table 4 is a grouped frequency distribution showing the portion of the population requiring more than +.25 diopters of minus cylinder under stereoscopic conditions, that portion requiring +.25 diopters and that portion requiring less than +.25 diopters, for each eye. Again, this illustrates that there is no relationship between right and left eyes when the data is grouped around the median figure; however, a relationship does exist between right and left eyes when the data is at the extremes, (above and below).

This data was again computed in the form of a chi squared equation in order to determine the significance of the relationship between right and left eyes with the data grouped around the extremes. Chi squared = 2.630. With two degrees of freedom, the chi squared required to be significant at the five percent level of probability is 5.99. Obviously the chi squared computed on our data is not statistically significant. It is our contention, however, that a significant relationship would exist if a larger sample of patients were used. In our sample there are 28 patients. A population of approximately twice the number of patients should show the relationships we have talked about.

The "t" scores shown in Tables 1 and 2 indicate that this data on change in cylinder power is significant at well beyond the 0.1% level of probability -- ie: there is less than a one in a thousand chance that the results could have been obtained by chance. From this we can definitely say that when comparing stereoscopic refraction to bi-dimensional refraction there is the <u>highest</u> probability that the patient will require more minus cylinder power under stereoscopic conditions with a mean value of about .25 diopters.

O.S.

O.D.	-.50	-.375	-.25	-.125	0	+.125	+.25	+.375	+.50	+.625	+.75
+.75											
+.625						1					
+.50							1111		11	1	
+.375							11	1			
+.25					11	1	11 111		1		
+.125			1			11	11	1			
0							1				
-.125							1				
-.25							11				
-.375											
-.50											

TABLE 3

O.D.		O.S. below .25	O.S. .25	O.S. above .25	total OD
	above .25	1	5	4	10
	.25	3	5	1	9
	below .25	3	5	1	9
	total OS	7	15	6	

Chi squared = 2.630, with two degrees of freedom.

TABLE 4

CONCLUSION:

It has long been the contention of those using stereoscopic refraction techniques that these techniques more nearly represent the normal every-day seeing environment. It is not our purpose in this research thesis to attempt to sway anyone's view on this particular point; rather, to try to inform practitioners using either technique that a significant difference in results does exist. It is up to the individual practitioner to decide which refraction technique will best serve his patients' needs.

It is our genuine hope that this thesis may, in some way, be a worthwhile addition to the accumulated knowledge of the profession to which we dedicate our services.

Gary E. Eudaily

Jon Elston

Larry Henningsgaard

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